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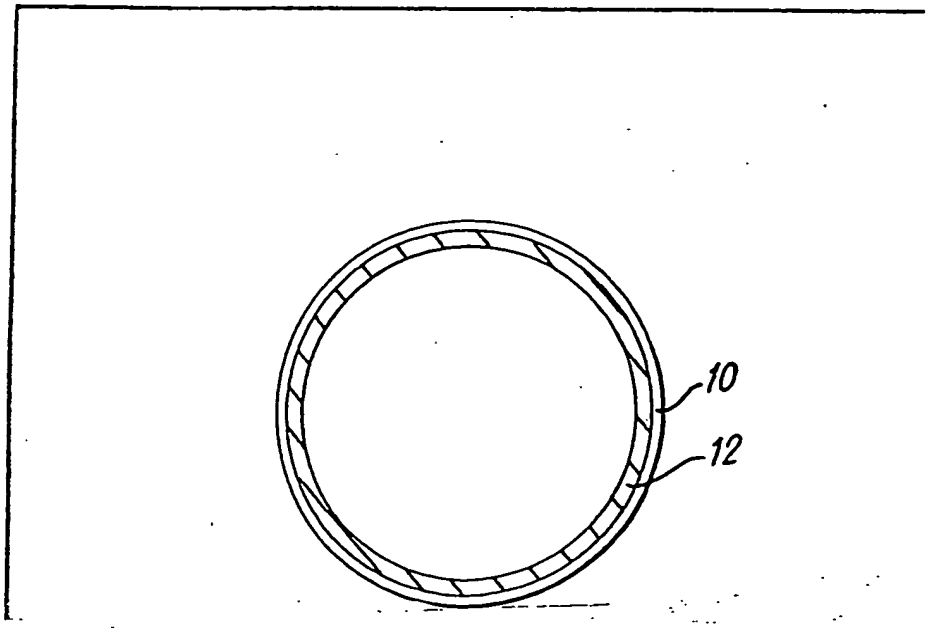
(54) Lined Hollow Shafts

(57) A hollow member, much as a shaft 10 for a vehicle drive has a fibre reinforced synthetic resinous material lining 12 which is applied by covering a deformable core of external dimensions less than the corresponding internal dimensions of the hollow member with fibre reinforced synthetic resinous material inserting the core and its covering into the hollow member, deforming the core to bring the covering into intimate contact with the interior of the hollow member, maintaining this deformation until th resinous material has cured sufficiently and thereafter allowing t core to return to an undeformed sta whereby it may be withdrawn from the lined hollow member. As shown the hollow shaft 10 to be lined may made of stainless steel, other metals and alloys or plastics or fibre reinforced material. The resinous lining 12 may be reinforced with carbon fibres. The core may be of rubber or plastics and expanded by heating rods (14), elements (16), a h air duct (18) or by fluid pressure.



ERRATUM

SPECIFICATION NO 2059546A

Page 2, line 11, *after* Claims *insert* filed on 8.9.80

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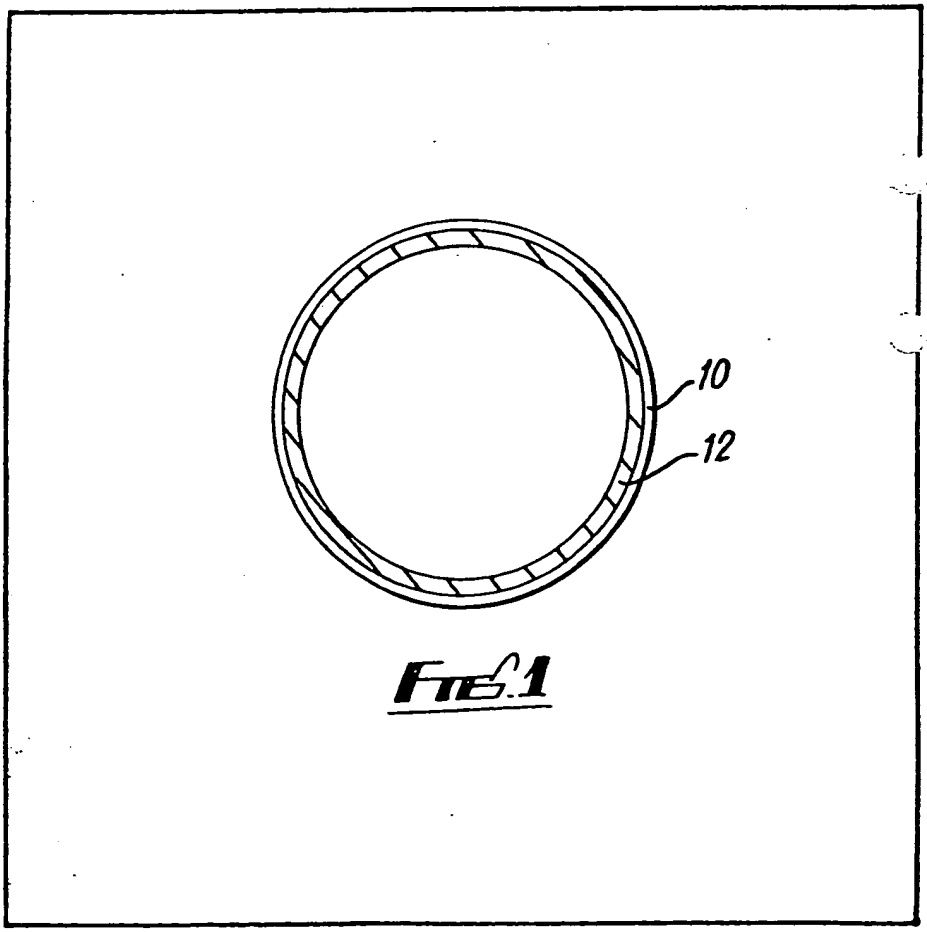

FIG.1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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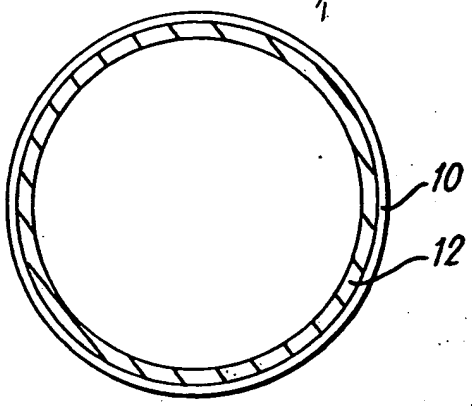

FIG.1

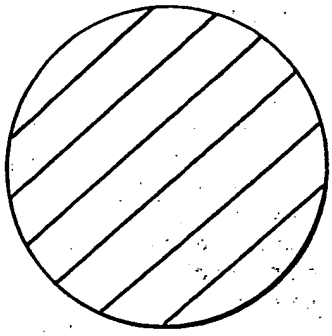

FIG.2

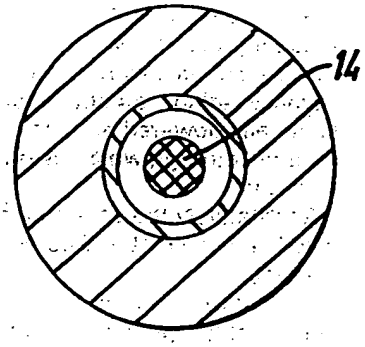

FIG.3

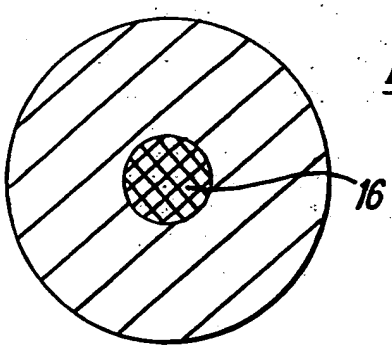

FIG.4

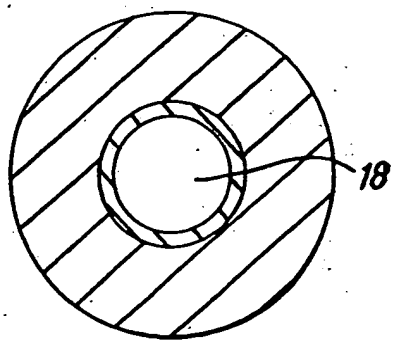

FIG.5

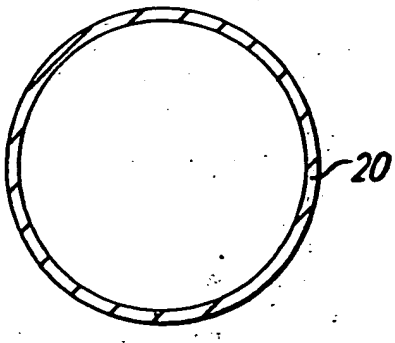

FIG.6

SPECIFICATION

Method for Lining Hollow Members

The present invention concerns an improved method for lining hollow members, for example tubes, and lined hollow members when manufactured by said method.

According to the present invention there is provided a method of lining a hollow member with a fibre reinforced synthetic resinous material comprising covering a deformable core of external dimensions less than the corresponding internal dimensions of the hollow member with material and reinforcement, inserting the core and its covering into the hollow member, deforming the core to bring the covering into intimate contact with the interior of the hollow member, maintaining this deformation until the material has cured sufficiently and thereafter allowing the core to return to an undeformed state whereby it may be withdrawn from the lined hollow member.

The core may be solid and manufactured from a material having a co-efficient of expansion greater than that of the hollow member whereby on heating the core will expand and exert pressure on the covering. The core may have an internal heating element which may be electrically powered or it may have internal passages through which heating fluid may be circulated.

Alternatively the core may be hollow, thin-walled and resilient and deformed by pressurising its interior.

The reinforcing may be in the form of a woven cloth pre-impregnated with the synthetic resinous material or may comprise a plurality of unidirectionally arranged fibres. The fibres may be located in grooves formed in the exterior of the core.

Preferably the hollow member is a stainless steel tube and the reinforcement in the synthetic resinous material is carbon fibres. Alternatively the hollow member may be manufactured from any other metal, alloy, plastics material, or fibre reinforced material and may have any suitable cross-section, the corresponding cross-section of the core substantially conforming to the cross-section of the interior of the hollow member.

The ends of the core may be covered by a reinforced synthetic resinous material.

The invention provides also a lined hollow member when manufactured by any of the methods described in the preceding paragraphs.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Fig. 1 shows a cross-section of a lined stainless steel tube; and

Figs. 2 to 6 show cross-sections of various cores which can be utilised in the lining of the tube shown in Fig. 1.

A stainl ss steel tub 10 comprises a lining of a synth tic resinous mat rial 12 having carbon fibres (not shown) embedded therein to provide reinforcement. The axes of the carbon fibres are substantially parallel to the axis of the tube, the resinous material being bonded to the inside wall of the tube. A lined tube of this nature is advantageous in that it utilises the high strength and the modul of the stainless steel, it can be manufactured from readily available thin walled seamless stainless steel tube, it has good corrosion resistance and it utilises the high specific strength and modulous of the carbon fibres. A rotating tube of this nature can thus be used as a vehicle propeller shaft and can be employed in longer lengths than hitherto possible with conventional propellor shafts, which are subject to distortion partly due to the lower specific stiffness and self-mass of the thick walled tube forming the shaft. Thus the stiffer and lighter tube of the embodiment enables the rotational speed of a propellor shaft to be increased to the maximum and/or the unsupported length of the shaft to be increased to the maximum.

In operation of such a tube the outer shell could be used to transmit all or substantially all of the torsional loads while the inner lining is used mainly to stiffen the tube in its longitudinal axis and to provide support for the thin walled steel shell.

In manufacture the stainless steel tube has any required attachments added prior to the lining being bonded thereto.

A solid rubber core of the type shown in Fig. 2 has an external diameter less than the internal diameter of the tube and is wrapped with the correct amount of pre-impregnated carbon fibres and any other components so that the final outside diameter is slightly less than the internal diameter of the tube.

The covered core is then placed inside the tube or assembly and heat is used to cure the resin in the carbon fibre pre-impregnation whilst pressure is applied from inside the tube. The pressure is applied due to the relatively large coefficient of thermal expansion of rubber, and due to the differential expansion between the tube and core pressure is developed against the inside walls of the steel tube.

In this method it may be preferred that heat is applied from inside the assembly, so that the rubber is fully expanded before the resin in the pre-impregnation cures. This may be achieved by using heating rods 14 (Fig. 3) elements 16 (Fig. 4) or a hot air/fluid medium passed through a passage 18 in the core (Fig. 5).

The pressurising of the lining may be achieved by the expansion of a thin walled rubber or plastic tube 20 (Fig. 6) by air or hydraulic pressure. Th pressurising medium may als be used to heat the assembly.

The external surface of the core may be grooved to orientate fibres or bundles of fibres.

Many variations of construction and materials of the inner and outer tubes are possible, the exact choice of materials and design being dictat d by the mechanical and chemical requir ments.

Various internal and external profiles may be produced by the method.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to whether or not particular emphasis has been placed thereon.

Claims

1. A method of lining a hollow member with a fibre reinforced synthetic resinous material comprising covering a deformable core of external dimensions less than the corresponding internal dimensions of the hollow member with material and reinforcement, inserting the core and its covering into the hollow member, deforming the core to bring the covering into intimate contact with the interior of the hollow member, maintaining this deformation until the material has cured sufficiently and thereafter allowing the core to return to an undeformed state whereby it may be withdrawn from the lined hollow member.

2. A method as claimed in claim 1, in which the core is solid and manufactured from a material having a co-efficient of expansion greater than that of the hollow member whereby on heating the core will expand and exert pressure on the covering.

3. A method as claimed in claim 2, in which the core is heated by an internal heating element.

4. A method as claimed in claim 3, in which the heating element is electrically powered.

5. A method as claimed in claim 3, in which the heating element is heated by circulating heating fluid through internal passages.

6. A method as claimed in claim 1, in which the core is hollow, thin-walled and resilient and deformed by pressurising its interior.

7. A method as claimed in any one of the preceding claims, in which the reinforcing is in the form of a woven cloth pre-impregnated with the synthetic resinous material.

8. A method as claimed in any one of claims 1 to 6, in which the reinforcing comprises a plurality of unidirectionally arranged fibres.

9. A method as claimed in claim 8, in which the fibres are located in grooves formed in the exterior of the core.

10. A method as claimed in any one of the preceding claims, in which the hollow member is a stainless steel tube and the reinforcement in the synthetic resinous material is carbon fibres.

11. A method as claimed in any one of claims 1 to 9, in which the hollow member is manufactured from metal, alloy, plastics material, or fibre reinforced material and has any suitable cross section, the corresponding cross-section of the core substantially conforming to the cross-section of the interior of the hollow member.

12. A method as claimed in any one of the preceding claims in which the hollow member is formed from a plurality of separable parts such that after the lining has cured it can be separated from the tube.

13. A method as claimed in any one of th preceding claims in which the ends of the core are covered by a reinforced synthetic resinous material.

14. A method substantially as hereinbefore described with reference to any one of the figures of the accompanying drawings.

15. A lined hollow member when manufactured by a method claimed in any one of the preceding claims.

16. Any novel subject matter or combination including novel subject matter herein disclosed, whether or not within the scope of or relating to the same invention as any of the preceding claims.

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